

## APPENDIX G -- SUBASSEMBLY

### G1. LIFEBOAT RACK INSTALLER

Table G-1. Lifeboat Rack Installer RULA

*Rapid Upper Limb Assessment (RULA)*  
Matamney and Corlett (1993)

Work Phase	Torchcutting		Grind Squatting		Grind Stooped		Move Workpiece		Wire Weld Kneeling		Adjust Pos. w/ Sledge	
	Spec	RULA	Spec	RULA	Spec	RULA	Spec	RULA	Spec	RULA	Spec	RULA
Shoulder Extension/ Flexion	sl flx	2	sl flx	2	mod flex	3	mod flex	3	sl flx	2	sl flx	2
Shoulder is Raised (+1)		0		0		0		0		0		0
Upper Arm Abducted (+1)		0		0		0		0		0		0
Arm supported, leaning (-1)		0		0		0		0		0		0
Elbow Extension/ Flexion	ext	1	ext	1	ext	1	ext	1	ext	1	ext	1
Shoulder Abduction/ Adduction	neut	0	add	1	add	1	add	1	neut	0	neut	0
Shoulder Lateral/ Medial* *not included in RULA analysis	neut	0	mod med	0	mod med	0	mod med	0	neut	0	neut	0
Wrist Extension/ Flexion	ext	2	ext	2	ext	2	flx	2	flx	2	ext	2
Wrist Deviation	ulnar	1	ulnar	1	ulnar	1	neut	0	ulnar	1	ulnar	1
Wrist Twist (1) In mid range or (2) End of range		1		1		1		1		1		1
Arm Wrist Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		0		0		0
Arm and Wrist Force/ Load Score: If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		2		2		1		1		1

Table G-1. Lifeboat Rack Installer RULA (continued)

Work Phase	Torchcutting		Grind Squatting		Grind Stooped		Move Workpiece		Wire Weld Kneeling		Adjust Pos. w/ Sledge	
	Spec	RULA	Spec	RULA	Spec	RULA	Spec	RULA	Spec	RULA	Spec	RULA
Neck Extension/ Flexion	ext	4	sl flx	2	ext	4	ext	4	sl flx	2	sl flx	2
Neck Twist (+1)		0		0		0		0		0		0
Neck Side-Bent (+1)		0		0		0		0		0		0
Trunk Extension/ Flexion	mod flx	3	sl flx	2	hyp flx	4	hyp flx	4	sl flx	2	mod flx	3
Trunk Twist (+1)		0		0		0		0		0		1
Trunk Side Bend (+1)		0		0		0		0		0		0
Legs: If legs and feet are supported and balanced: (+1); if not: (+2)		1		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		0		0		0
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		2		2		1		1		1
<b>Total RULA Score</b>	<b>6</b>		<b>7</b>		<b>7</b>		<b>5</b>		<b>4</b>		<b>5</b>	
<p>1 or 2 = Acceptable            3 or 4 = Investigate Further            5 or 6 = Investigate Further and Change Soon            7 = Investigate and Change Immediately</p>												

Table G-2. Lifeboat Rack Installer Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>3.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= 100 x duration of all exertions (sec)	10% - 29%	2	1.0
Total observation time (sec)	30% - 49%	3	1.5
= 100 x 1896 (sec)/3173 (sec)	50% - 79%	4	2.0
= 60%	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>2.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= number of exertions	4 - 8	2	1.0
total observation time (min)	9 - 14	3	1.5
= 118/53 = 2.2, but task somewhat static,	15 - 19	4	2.0
set multiplier to 1.0	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>1.0</b>

Table G-2. Lifeboat Rack Installer Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
<b>Rating Criterion</b>	<b>Wrist Extension</b>	<b>Wrist Flexion</b>	<b>Ulnar Deviation</b>	<b>Perceived Posture</b>	<b>Rating</b>	<b>Multiplier</b>
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral (*estimated, based on RULAs done)	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>1.5</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
<b>Rating Criterion</b>	<b>Observed Pace/MTM Predicted Pace x 100%</b>	<b>Perceived Speed</b>	<b>Rating</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:			
Duration of Task per Day (hrs)	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
= duration of task (hrs) +	< or = 1 hr	1	0.25
duration of task (hrs) + ...	1 – 2 hrs	2	0.50
	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
= (estimate ~ 4 - 8 hrs)	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>1.00</b>

Table G-2. Lifeboat Rack Installer Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>S I SCORE</u>
<b>3.0 X</b>	<b>2.0 X</b>	<b>1.0 X</b>	<b>1.5 X</b>	<b>1.0 X</b>	<b>1.00</b>		<b>2</b>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table G-3. Lifeboat Rack Installer UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

Risk Factors	No	Yes
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges		Y
1.2 Is the tool operating without vibration?	N	
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?		Y
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?		Y
6.3 Is the handle of the tool made from material other than metal?	N (grinder)	
6.4 Is the weight of the tool below 4 kg (9lbs)?	N (grinder)	
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	<b>16 (73%)</b>	<b>6 (27%)</b>

Table G-4. Lifeboat Rack Installer OWAS

*OWAS: OVAKO Work Analysis System*  
 Louhevaara and Suurnäkki (1992)

Work Phase	Torch-cutting	Grind Squatting	Grind Stooped	Move Workpiece	Wire Weld Kneeling	Adjust Pos. w/ Sledge
TOTAL Combination Posture Score	2	2	2	2	2	2
Common Posture Combinations (collapsed across work phases)						
Back	2	2				
Arms	1	1				
Legs	6	4				
Posture Repetition (% of working time)	6	31				
Back % of Working Time Score	1	2				
Arms % of Working Time Score	1	1				
Legs % of Working Time Score	1	3				
ACTION CATEGORIES: 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately						

Table G-4. Lifeboat Rack Installer OWAS (continued)

<b>Work Phase</b>	<b>Torch-cutting</b>	<b>Grind Squatting</b>	<b>Grind Stooped</b>	<b>Move Workpiece</b>	<b>Wire Weld Kneeling</b>	<b>Adjust Pos. with Sledge</b>
<b>Posture</b>						
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	2	2	2	2	2
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	6	4	4	4	6	4
<b>Load/ Use of Force</b>						
1 = weight or force needed is = or <10 kg (<22lbs) 2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs) 3 = weight or force > 20 kg (>44 lbs)	1	1	1	2	1	1
<b>Phase Repetition</b>						
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	4	14	6	6	2	5

Table G-5. Lifeboat Rack Installer 3D Static Strength Prediction Program

*3D Static Strength Prediction Program*  
University of Michigan (1997)

Work Phase: Moving Workpiece (30 lbs estimated)	Disc Compression (lbs) @ L5/S1 (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs)
<p>Worker lifts end of angle into place</p> 	<p>769 pounds</p>

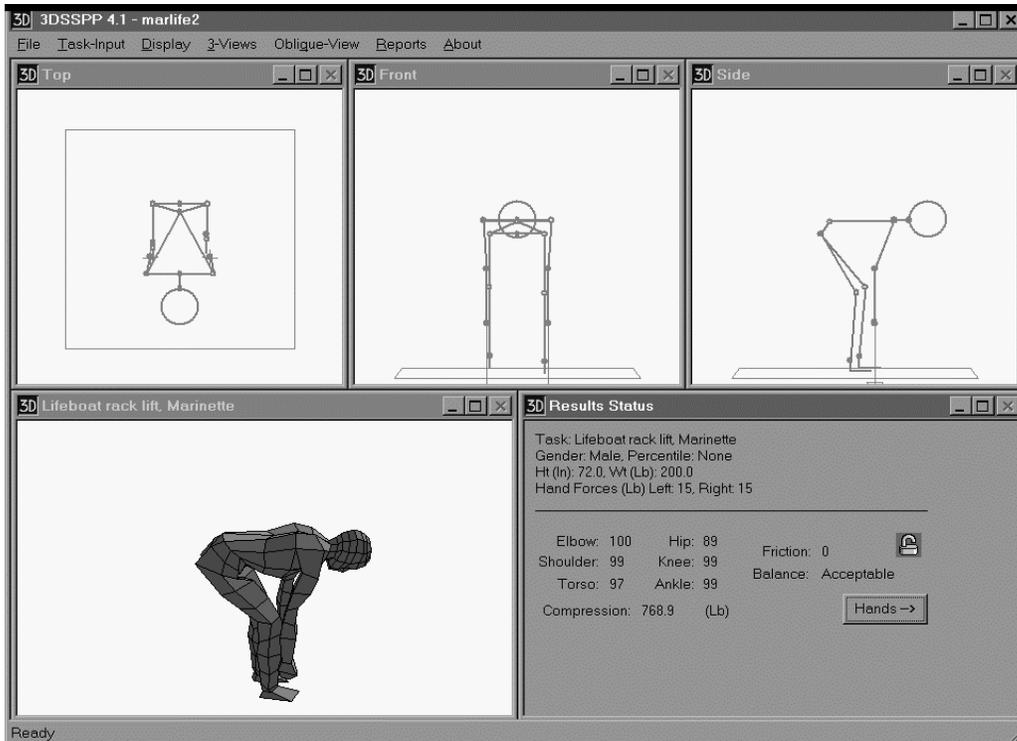


Table G-6. Lifeboat Rack Installer PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions					
2) Answer questions, score potential body regions for injury risk					
<b>Musculoskeletal Risk Factor Questions</b>	<b>Body Regions</b>				
	Neck, Shoulder, Upper Back	Elbows, Forearms Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? e.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			Y	Y	Y
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table G-6. Lifeboat Rack Installer PLIBEL (continued)

10: Is repeated/sustained work performed with neck:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	Y				
11: Are loads lifted manually? Note important factors:					
a) periods of repetitive lifting	N				N
b) weight of load	N				N
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	Y				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed?					
a) weight of working materials or tools	N	N			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Repeated work, with forearm and hand, performed w/:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table G-6. Lifeboat Rack Installer PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, Upper Back	Elbows, Forearm, Hands	Feet	Knees and Hips	Low Back
SUM	16	7	3	3	12
PERCENTAGE	61.5	63.6	37.5	37.5	57.1
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work?	N				
20: Is the job performed under time demands or psychological stress?	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	Y				
f) jerks, shakes, or vibration	Y				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	6				
PERCENTAGE	60.0				

## G2. BOW ASSEMBLY SHIPFITTER

Table G-7. Bow Assembly Shipfitter RULA

*Rapid Upper Limb Assessment (RULA)*  
Matamney and Corlett (1993)

Work Phase	Torchcut		Change Tool		Reposition		Inspect, set level		Attach/Adjust Comealong and Chains		Crank Comealong	
	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score
Shoulder Extension/ Flexion	mod flx	3	sl flx	2	mod flex	3	sl flx	2	hyp flx	4	hyp flx	4
Shoulder is Raised (+1)		0		0		0		0		1		1
Upper Arm Abducted (+1)		0		0		0		0		0		0
Arm supported, leaning (-1)		-1		0		0		0		0		0
Elbow Extension/ Flexion	ext	1	ext	1	ext	1	ext	1	ext	1	ext	1
Shoulder Abduction/ Adduction	neut	0	neut	0	neut	0	neut	0	add	1	neut	0
Shoulder Lateral/ Medial* *not included in RULA analysis	neut	0	neut	0	neut	0	neut	0	mod med	0	lat	0
Wrist Extension/ Flexion	ext	2	neut	0	neut	0	flx	2	ext	2	flx	2
Wrist Deviation	ulnar	1	neut	0	neut	0	neut	0	ulnar	1	rad	1
Wrist Twist (1) In mid range or (2) End of range		1		1		1		1		1		1
Arm/Wrist Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+ 1)		0		0		0		0		0		1
Arm and Wrist Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		1		1		1		1		3

Table G-7. Bow Assembly Shipfitter RULA (continued)

RULA Component	Torchcut		Change Tool		Reposition		Inspect, set level		Attach/ Adjust Comealong and Chains		Crank Comealong	
	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score
Neck Extension/ Flexion	ext	4	sl flx	2	sl flx	2	flx	3	ext	4	ext	4
Neck Twist (+1)		0		0		0		1		0		0
Neck Side-Bent (+1)		0		0		0		1		0		0
Trunk Extension/ Flexion	mod flx	3	sl flx	2	sl flx	2	sl flx	2	neut	1	neut	1
Trunk Twist (+1)		0		0		0		0		0		0
Trunk Side Bend (+1)		1		0		0		1		0		0
Legs: If legs and feet are supported and balanced: (+1); If not: (+2)		1		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+ 1)		0		0		0		0		0		0
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		1		1		1		1		2
<b>Total RULA Score</b>	<b>5</b>		<b>3</b>		<b>3</b>		<b>4</b>		<b>6</b>		<b>6</b>	
<p>1 or 2 = Acceptable            3 or 4 = Investigate Further            5 or 6 = Investigate Further and Change Soon            7 = Investigate and Change Immediately</p>												

Table G-8. Bow Assembly Shipfitter Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>3.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= 100 x duration of all exertions (sec)	10% - 29%	2	1.0
Total observation time (sec)	30% - 49%	3	1.5
= 100 x 301 (sec) / 1311 (sec)	50% - 79%	4	2.0
= 23%	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>1.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= number of exertions	4 - 8	2	1.0
total observation time (min)	9 - 14	3	1.5
= 38 / 22 = 1.7	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>0.5</b>

Table G-8. Bow Assembly Shipfitter Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
<b>Rating Criterion</b>	<b>Wrist Extension</b>	<b>Wrist Flexion</b>	<b>Ulnar Deviation</b>	<b>Perceived Posture</b>	<b>Rating</b>	<b>Multiplier</b>
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral (*estimated, based on RULAs done)	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>1.5</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
<b>Rating Criterion</b>	<b>Observed Pace/MTM Predicted Pace x 100%</b>	<b>Perceived Speed</b>	<b>Rating</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:			
Duration of Task per Day (hrs)	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
= duration of task (hrs) +	< or = 1 hr	1	0.25
duration of task (hrs) + ...	1 – 2 hrs	2	0.50
	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
= (estimate ~ 4 - 8 hrs)	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>1.00</b>

Table G-8. Bow Assembly Shipfitter Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
<b>3.0 X</b>	<b>1.0 X</b>	<b>0.5 X</b>	<b>1.5 X</b>	<b>1.0 X</b>	<b>1.00</b>		<b><u>2.25</u></b>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table G-9. Bow Assembly Shipfitter UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

Risk Factors	No	Yes
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges		Y
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?		Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?		Y
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?		Y
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?		
6.3 Is the handle of the tool made from material other than metal?	N	
6.4 Is the weight of the tool below 4 kg (9lbs)?	N	
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	<b>13 (65%)</b>	<b>7 (35%)</b>

Table G-10. Bow Assembly Shipfitter OWAS

*OWAS: OVAKO Work Analysis System*  
 Louhevaara and Suurnäkki (1992)

Work Phase	Torchcut	Change Tool	Reposition	Inspect, Set Level	Attach/ Adjust Come-along and Chains	Crank Come-along
TOTAL Combination Posture Score	2	1	1	2	1	1
Common Posture Combinations (collapsed across work phases)						
Back	2	1	1	1		
Arms	1	1	1	3		
Legs	1	1	7	2		
Posture Repetition (% of working time)	49	2	29	17		
Back % of Working Time Score	2	1	1	1		
Arms % of Working Time Score	1	1	1	1		
Legs % of Working Time Score	1	1	1	1		
ACTION CATEGORIES: 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately						

Table G-10. Bow Assembly Shipfitter OWAS (continued)

Work Phase	Torchcut	Tool	Reposition	Inspect, Set Level	Attach/ Adjust Come-along and Chains	Come-along
<b>Posture</b>						
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	1	1	2	1	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	3	3
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	1	1	7	1,7	2	2
<b>Load/ Use of Force</b>						
1 = weight or force needed is = or <10 kg (<22lbs) 2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs) 3 = weight or force > 20 kg (>44 lbs)	1	1	1	1	1	2
<b>Phase Repetition</b>						
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	4	2	29	45	14	3

Table G-11. Bow Assembly Shipfitter PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions					
2) Answer questions, score potential body regions for injury risk					
<b>Musculoskeletal Risk Factor Questions</b>	<b>Body Regions</b>				
	Neck, Shoulder, Upper Back	Elbows, Forearms Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	Y	Y	Y	Y	Y
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	n/a				n/a
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? e.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	N				N

Table G-11. Bow Assembly Shipfitter PLIBEL (continued)

10: Is repeated/sustained work performed with neck:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	Y				
11: Are loads lifted manually? Note important factors:					
a) periods of repetitive lifting	N				N
b) weight of load	N				N
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	N				N
e) handling beyond forearm length	N				N
f) handling below knee length	N				N
g) handling above shoulder height	Y				Y
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	N	N			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed?					
a) weight of working materials or tools	N	N			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Repeated work, with forearm and hand, performed w/:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table G-11. Bow Assembly Shipfitter PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	14	7	3	3	10
PERCENTAGE	53.8	63.6	37.5	37.5	47.6
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work?	N				
20: Is the job performed under time demands or psychological stress?	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	N				
b) heat	Y				
c) draft	N				
d) noise	Y				
e) troublesome visual conditions	Y				
f) jerks, shakes, or vibration	N				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	3				
PERCENTAGE	30.0				

### G3. RAKE FRAME SHIPFITTER

Table G-12. Rake Frame Shipfitter Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>6.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= 100 x duration of all exertions (sec)	10% - 29%	2	1.0
Total observation time (sec)	30% - 49%	3	1.5
= 100 x 546 (sec)/984 (sec)	50% - 79%	4	2.0
= 55%	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>2.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= number of exertions	4 - 8	2	1.0
total observation time (min)	9 - 14	3	1.5
= 67/16.39 = 4.1	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>1.0</b>

Table G-12. Rake Frame Shipfitter Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
Rating Criterion	Wrist Extension	Wrist Flexion	Ulnar Deviation	Perceived Posture	Rating	Multiplier
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral (*estimated)	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>1.0</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
Rating Criterion	Observed Pace/MTM Predicted Pace x 100%	Perceived Speed	Rating	Multiplier
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:	Rating Criterion	Rating	Multiplier
Duration of Task per Day (hrs)	< or = 1 hr	1	0.25
= duration of task (hrs) +	1 – 2 hrs	2	0.50
duration of task (hrs) + ...	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
= (estimate ~ 2 - 4 hrs)	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>0.75</b>

Table G-12. Rake Frame Shipfitter Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
6.0 X	2.0 X	1.0 X	1.0 X	1.0 X	0.75		9

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table G-13. Rake Frame Shipfitter UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

Risk Factors	No*	Yes
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10 lbs.) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	n/a	n/a
3.3 Can the job be done without deviating the wrist from side to side?		Y
3.4 Can the tool be used without deviating the wrist from side to side?		Y
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	n/a	n/a
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?		Y
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	n/a	n/a
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?	n/a	n/a
6.3 Is the handle of the tool made from material other than metal?	n/a	n/a
6.4 Is the weight of the tool below 4 kg (9 lbs.)?	n/a	n/a
6.5 Is the tool suspended?	n/a	n/a
<b>TOTAL</b>	<b>8</b>	<b>7</b>

Table G-14. Rake Frame Shipfitter OWAS

*OWAS: OVAKO Work Analysis System*  
 Louhevaara and Suurnäkki (1992)

Work Phase	Place Angle Irons	Clamp/ Unclamp	Hammer Wedges	Deslag	Stage Angles	Rest	Undefined	Torch Cut	Place Angle Pieces
TOTAL Combination Posture Score	3,4	2,4	2,4	2,4	3,4	1	1	2	2,3,4
Common Posture Combinations (collapsed across work phases)									
Back	4	1	2	4	2	2	1		
Arms	1	1	1	1	1	1	1		
Legs	7	1	4	4	7	4	2		
Posture Repetition (% of working time)	51	45	4	51	51	55	4		
Back % of Working Time Score	3	1	1	3	2	2	1		
Arms % of Working Time Score	1	1	1	1	1	1	1		
Legs % of Working Time Score	1	1	1	3	1	3	1		
ACTION CATEGORIES: 1 = No corrective measures 2 = Corrective measures in near future 3 = Corrective measures as soon as possible 4 = Corrective measures immediately									

Table G-14. Rake Frame Shipfitter OWAS (continued)

Work Phase	Place Angle Irons	Clamp/ Unclamp	Hammer Wedges	Deslag	Stage Angles	Rest	Undefined	Torch Cut	Place Angle Pieces
<b>Posture</b>									
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2,4	2,4	2,4	2,4	2,4	1	1	2	2,4
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	7	4,7	4,7	4,7	4,7	1,2	1,2	4	4,7
<b>Load/Use of Force</b> 1 = weight or force needed is ~ or < 10 kg (<22 lb) 2 = weight or force > 10 but < 20 kg (> 22 lb, < 44lb) 3 = weight or force is > 20 kg (> 44lb)	3	1	1	1	3	1	1	1	2
<b>Phase Repetition</b> % of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	10	18	7	13	1	5	40	4	2

Table G-15. Rake Frame Shipfitter NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
Waters and Putz-Anderson (1996)

\* “YES” responses are indicative of conditions that pose a risk of developing low back pain;  
the larger the percentage of “YES” responses, the greater the risk

<b>RISK FACTORS</b>	<b>YES</b>	<b>NO</b>
<b>General</b>		
1.1 Does the load handled exceed 50 lb?	Y (usually)	
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?	Y (fixtures in way)	
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?		N
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (extreme lumbar flexion)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?	Y (welding, machinery in proximity)	
1.9 Does the task require working in a confined area?		N
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N (LPM = 0.67 over total cycle time, but lifts are performed in rapid succession at a frequency of 2 LPM)
2.2 Does the vertical lifting distance exceed 3 feet?		N (seldom)
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?		N (usually <= 10)
2.5 Do extended reach static holding tasks exceed 1 minute?		N
<b>TOTAL</b>	<b>6 (43%)</b>	<b>8 (57%)</b>

Table G-16. Rake Frame Shipfitter 3D Static Strength Prediction Program

*3D Static Strength Prediction Program*  
University of Michigan (1997)

<b>Work Phases: Manual Placement of Angle Iron Rake Frame Components</b>	<b>Disc Compression (lb) @ L5/S1 (Note: NIOSH Recommended Compression Limit (RCL) is 770 lb)</b>
<b>Angle RF2</b> weighs 133 lb; lifts one end off stack, pivots angle, then drops into place; 33.25 lb per arm	<b>1389 lb</b> (middle of lift)
<b>Curved angle RF1</b> weighs 246 lb; lifts one end, pivots into place, lowers load with control; 123 lb lifted, 61.5 lb per arm	<b>857 lb</b> (middle of lift) <b>1531 lb</b> (end of lift)
<b>Angle RF3</b> weighs 125 lb; lifts one end off stack, and pivots in place, lowers load, then drops into place; lifts @ 62.5 lb or 31.25 lb per arm	<b>926 lb</b> (beginning of lift) 597 lb (middle of lift) <b>1021 lb</b> (end of lift)
<b>Angle RF4</b> weighs 47 lb; shipfitter lifts one end with one hand; lifts 23.5 lb by right arm, then lowers entire angle; lifts 23.5 lb per arm	<b>854 lb</b> (beginning of lift) 691 lb (middle of lift)
<b>Angle RT-3</b> weighs 65 lb; lifts one end with one hand off stack; 32.5 lb by right arm. Then uses two arms to carry angle into place; 32.5 lb per arm.	<b>1009 lb</b> (beginning of lift) 551lb (middle of lift)
<b>Angle RT-1</b> weighs 95 lb; lifts one end with one hand off stack before using two hands to drag it into place; 47.5 lb by right arm for initial lift.	<b>926 lb</b> (beginning of lift)
<b>Angle RT-2</b> weighs 70 lb; lifts one end with one hand off stack before using two hands to drag it into place; 35 lb by right arm.	709 lb (beginning of lift)
<b>Angle RF-5</b> weighs 52 lb; lifts one end with both hands off stack before using two hands to lift it into place; 26 lb lifted per arm	<b>1187 lb</b> (beginning of lift) 668 lb (middle of lift)

Table G-17. Rake Frame Shipfitter PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
Methods of Application: 1) Find the injured body region, answer yes or no to corresponding questions, or 2) Answer questions, score potential body regions for injury risk.					
Musculoskeletal Risk Factor Questions	Body Regions				
	Neck, Shoulder, and Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	Y	Y	Y	Y	Y
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	N				N
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? For example, ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	Y				Y

Table G-17. Rake Frame Shipfitter PLIBEL (continued)

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	Y				Y
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing, or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work with forearm and hand done with:					
a) twisting movements?		Y			
b) forceful movements?		Y			
c) uncomfortable hand positions?		N			
d) switches or keyboards?		N			

Table G-17. Rake Frame Shipfitter PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, and Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	20	9	3	3	15
PERCENTAGE	76.9	81.8	37.5	37.5	71.4
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work?	Y				
20: Is the job performed under time demands or psychological stress?	Y				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	N				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	Y				
f) jerks, shakes, or vibration	N				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	6				
PERCENTAGE	60.0				

## G4. RAKE FRAME WELDER

Table G-18. Rake Frame Welders RULA

*Rapid Upper Limb Assessment (RULA)*  
Matamney and Corlett (1993)

Work Phase	Welding Inside Frame		Welding Straddle Frame		Deslag		Welding Outside Frame		Composite of Work Phases	
	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score
Shoulder Extension/ Flexion	mod flex	3	sl flex	2	sl flex	2	sl flex	2	sl flex (53%)	2
Shoulder is Raised (+1)		0		0		0		0		0
Upper Arm Abducted (+1)		0		0		0		0		0
Arm supported, leaning (-1)		-1		-1		-1		-1		-1
Elbow Extension/ Flexion	neut	2	ext	1	ext	1	flex	2	ext (61%)	1
Shoulder Abduction/ Adduction	add	1	add	1	add	1	mod abd	1	neut (50%)	0
Shoulder Lateral/ Medial	neut	0	mod med	1	mod med	1	mod med	1	neut (51%)	0
Wrist Extension/ Flexion	ext	2	ext	2	ext	2	ext	2	ext (64%)	2
Wrist Deviation Bent from Midline (+1)	ulnar	1	radial	1	neut	0	ulnar	1	neut (33%)	0
Wrist Twist (+1) In mid range, or (+2) End of range		1		1		1		1		1
Arm and Wrist Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+1)		1		1		1		1		1
Arm and Wrist Force/Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		2		2		2		2		2

Table G-18. Rake Frame Welders RULA (continued)

Work Phase	Welding Inside Frame		Welding Straddle Frame		Deslag		Welding Outside Frame		Composite of Work Phases	
	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score
Neck Twist (+1)		0		0		0		0		0
Neck Side Bend (+1)		0		0		0		0		0
Trunk Extension/Flexion	hyp flex	4	sl flex	2	hyp flex	4	hyp flex	4	hyp flex 100%	4
Trunk Twist (+1)		0		0		0		0		0
Trunk Side Bend (+1)		0		0		0		0		0
Legs: If legs and feet are supported and balanced : (+1); If not: (+2)		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (i.e., held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+1)		1		1		1		1		1
Neck, Trunk, and Leg Force/Load Score: If load less than 2 kg (intermittent): (+0) If 2 kg to 10 kg (intermittent): (+1) If 2 kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated of shocks: (+3)		3		2		3		3		3
<b>Total RULA Score</b>	<b>7</b>		<b>7</b>		<b>7</b>		<b>7</b>		<b>7</b>	
1 or 2 = Acceptable 3 or 4 = Investigate Further 5 or 6 = Investigate Further and Change Soon 7 = Investigate and Change Immediately										

Table G-19. Rake Frame Welder Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>3.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= 100 x duration of all exertions (sec)	10% - 29%	2	1.0
Total observation time (sec)	30% - 49%	3	1.5
= 100 x 2365 (sec)/3593 (sec)	50% - 79%	4	2.0
= 66%	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>2.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= number of exertions	4 - 8	2	1.0
total observation time (min)	9 - 14	3	1.5
= but task nearly static,	15 - 19	4	2.0
set multiplier to 3.0	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>3.0</b>

Table G-19. Rake Frame Welder Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
<b>Rating Criterion</b>	<b>Wrist Extension</b>	<b>Wrist Flexion</b>	<b>Ulnar Deviation</b>	<b>Perceived Posture</b>	<b>Rating</b>	<b>Multiplier</b>
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral (*estimated, based on RULAs done)	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>1.5</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
<b>Rating Criterion</b>	<b>Observed Pace/MTM Predicted Pace x 100%</b>	<b>Perceived Speed</b>	<b>Rating</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:			
Duration of Task per Day (hrs)	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
= duration of task (hrs) +	< or = 1 hr	1	0.25
duration of task (hrs) + ...	1 – 2 hrs	2	0.50
	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
= (estimate ~ 2 - 4 hrs)	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>0.75</b>

Table G-19. Rake Frame Welder Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
3.0 X	2.0 X	3.0 X	1.5 X	1.0 X	1.0		<u>27</u>

- SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:
- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
  - SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
  - SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
  - SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table G-20. Rake Frame Welder UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

Risk Factors	No	Yes
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges		Y
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lb) of force?		Y
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?		Y
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?		Y
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N (static)	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?		Y
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?		Y (handle)
6.3 Is the handle of the tool made from material other than metal?		Y
6.4 Is the weight of the tool below 4 kg (9lb)?		Y
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	<b>10</b>	<b>12</b>

Table G-21. Rake Frame Welder OWAS

*OWAS: OVAKO Work Analysis System*  
Louhevaara and Suurnäkki (1992)

Work Phase	Welding Inside Frame	Welding Straddle Frame	Deslag	Welding Outside Frame	Undefined	Resting	Guiding Crane Lowering Frame
Total Combination Posture Score	2	2	2	2	1	1	1
Common Posture Combinations (collapsed across work phases)							
Back	2	1	2	2	1		
Arms	1	1	1	1	1		
Legs	1	7	7	4	1		
Posture Repetition (% of working time)	16	8	3	55	29		
Back % of Working Time Score	2	1	1	2	1		
Arms % of Working Time Score	1	1	1	1	1		
Legs % of Working Time Score	1	1	1	3	1		
ACTION CATEGORIES: 1 = No corrective measures 2 = Corrective measures in near future 3 = Corrective measures as soon as possible 4 = Corrective measures immediately							

Table G-21. Rake Frame Welder OWAS (continued)

Work Phase	Welding Inside Frame	Welding Straddle Frame	Deslag	Welding Outside Frame	Undefined	Resting	Guiding Crane Lowering Frame
<b>Posture</b>							
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	2	2	2	1	1	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	1,4	1,4	7	4,7	7	1	7
<b>Load/Use of Force</b> 1 = weight or force needed is = or < 10 kg (< 22 lb) 2 = weight or force > 10 but < 20 kg (> 22 lb, < 44 lb) 3 = weight or force > 20 kg (> 44 lb)	1	1	1	1	1	1	1
<b>Phase Repetition</b> % of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	31	10	3	19	5	29	3

Table G-22. Rake Frame Welder PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
Methods of Application: 1) Find the injured body region, answer yes or no to corresponding questions, or 2) Answer questions, score potential body regions for injury risk.					
<b>Musculoskeletal Risk Factor Questions</b>	<b>Body Regions</b>				
	Neck, Shoulder, and Upper Back	Elbows, Forearms, and Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	N	N	N	N	N
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? e.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table G-22. Rake Frame Welder PLIBEL (continued)

10: Is repeated/sustained work performed with neck:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Note important factors:					
a) periods of repetitive lifting	N				N
b) weight of load	N				N
c) awkward grasping of load	N				N
d) awkward location of load at onset or end of lifting	N				N
e) handling beyond forearm length	N				N
f) handling below knee length	N				N
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	Y				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	Y				
17: Is repeated work with forearm and hand performed with:					
a) twisting movements?		N			
b) forceful movements?		N			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table G-22. Rake Frame Welder PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, and Upper Back	Elbows, Forearms, and Hands	Feet	Knees and Hips	Low Back
SUM	13	6	1	1	6
PERCENTAGE	50.0	54.5	12.5	12.5	28.6
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work?	Y				
20: Is the job performed under time demands or psychological stress?	Y				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	N				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	Y				
f) jerks, shakes, or vibration	N				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	6				
PERCENTAGE	60.0				

## G5. HATCH COVER ASSEMBLER

Table G-23. Hatch Cover Assembler RULA

*Rapid Upper Limb Assessment (RULA)*  
Matamney and Corlett (1993)

Work Phase	Punch Holes with Hammer		Unclamp Hatch		Remove/ Replace Hatch		Reclamp		Shoot Studs		Load Stud Gun	
	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score
Shoulder Extension/ Flexion	sl flex	2	sl flex	2	mod flx	3	sl flex	2	sl flex	2	neut	1
Shoulder is Raised (+1)		0		1		0		0		0		0
Upper Arm Abducted (+1)		0		1		1		0		1		0
Arm supported, leaning (-1)		0		0		0		0		-1		0
Elbow Extension/ Flexion	ext	1	ext	1	ext	1	ext	1	neut	2	neut	2
Shoulder Abduction/ Adduction	neut	0	mod abd	1	mod abd	1	neut	0	mod abd	1	mod abd	1
Shoulder Lateral/ Medial	neut	0	mod med	1	mod med	1	neut	0	mod med	1	mod med	1
Wrist Extension/ Flexion	ext	2	ext	2	ext	2	ext	2	ext	2	neut	1
Wrist Deviation	ulnar	1	rad	1	ulnar	1	ulnar	1	ulnar	1	neut	0
Wrist Bent from Midline (+1)		0		0		0		0		0		0
Wrist Twist (1) In mid range or (2) End of range		1		1		1		1		1		1
Arm and Wrist Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+ 1)		0		0		0		0		1		1
Arm and Wrist Force/ Load Score: If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		1		2		1		2		1

Table G-23. Hatch Cover Assembler, RULA (continued)

Work Phase	Punch Holes with Hammer		Unclamp Hatch		Remove/ Replace Hatch		Reclamp		Shoot Studs		Ggun	
	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score		RULA Score	Spec	RULA Score
Neck Extension/ Flexion	sl flx	2	sl flx	2	sl flx	2	flx	3	flx	3	flx	3
Neck Twist (+1)		0		0		0		0		0		0
Neck Side-Bent (+1)		0		0		0		0		0		0
Trunk Extension/ Flexion	mod flx	3	mod flx	3	sl flx	2	mod flx	3	hyp flx	4	neut	1
Trunk Twist (+1)		0		0		0		0		0		0
Trunk Side Bend (+1)		0		0		1		0		0		0
Legs: If legs and feet are supported and balanced: (+1); If not: (+2)		1		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+1)		0		0		0		0		1		1
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		1		2		1		1		1
<b>Total RULA Score</b>	<b>4</b>		<b>6</b>		<b>7</b>		<b>4</b>		<b>7</b>		<b>4</b>	
1 or 2 = Acceptable 3 or 4 = Investigate Further 5 or 6 = Investigate Further and Change Soon 7 = Investigate and Change Immediately												

Table G-24. Hatch Cover Assembler Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= 100 x duration of all exertions (sec)	10% - 29%	2	1.0
Total observation time (sec)	30% - 49%	3	1.5
= 100 x 413 (sec)/469 (sec)	50% - 79%	4	2.0
= 88%	> or = 80%	5	3.0
			<b>3.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= number of exertions	4 - 8	2	1.0
total observation time (min)	9 - 14	3	1.5
= 86/7.8 = 11	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>1.5</b>

Table G-24. Hatch Cover Assembler Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
Rating Criterion	Wrist Extension	Wrist Flexion	Ulnar Deviation	Perceived Posture	Rating	Multiplier
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	(*estimated, based on RULAs done)	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>2.0</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
Rating Criterion	Observed Pace/MTM Predicted Pace x 100%	Perceived Speed	Rating	Multiplier
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:	Rating Criterion	Rating	Multiplier
Duration of Task per Day (hrs)	< or = 1 hr	1	0.25
= duration of task (hrs) +	1 – 2 hrs	2	0.50
duration of task (hrs) + ...	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
= (estimate ~ 4- 8 hrs)	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			

Table G-24. Hatch Cover Assembler Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
<u>3.0 X</u>	<u>3.0 X</u>	<u>1.5 X</u>	<u>2.0 X</u>	<u>1.0 X</u>	<u>1.00</u>		<u>27</u>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table G-25. Hatch Cover Assembler UE CTD Checklist  
*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
 Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

Risk Factors	No	
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges		Y
1.2 Is the tool operating without vibration?	N	
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?		Y
1.4 Can the job be done without using gloves?		Y
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N (clamps)	
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?	N (clamps)	
6.3 Is the handle of the tool made from material other than metal?	N (clamps)	
6.4 Is the weight of the tool below 4 kg (9lbs)?	N (stud gun)	
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	<b>16 (76%)</b>	

Table G-26. Hatch Cover Assembler OWAS

*OWAS: OVAKO Work Analysis System*  
 Louhevaara and Suurnäkki (1992)

Work Phase	Holes with Hammer	Unclamp Hatch	Replace Hatch	Reclamp	Studs	Load Stud Gun
TOTAL Combination Posture Score	2	2	2	2	2	2
Common Posture Combinations (collapsed across work phases)						
Back	2	2	1			
Arms	1	1	1			
Legs	2	4	2			
Posture Repetition (% of working time)	22	35	32			
Back % of Working Time Score	1	2	1			
Arms % of Working Time Score	1	1	1			
Legs % of Working Time Score	1	3	1			
ACTION CATEGORIES: 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately						

Table G-26. Manhole Cover Assembler OWAS (continued)

Work Phase	Punch Holes with Hammer	Unclamp Hatch	Remove/ Replace Hatch	Reclamp	Shoot Studs	Gun
<b>Posture</b>						
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	2	2	2	2	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	2	2	4	2	4	2
<b>Load/ Use of Force</b>						
1 = weight or force needed is = or <10 kg (<22lbs) 2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs) 3 = weight or force > 20 kg (>44 lbs)	1	1	2	1	2	1
<b>Phase Repetition</b>						
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	9	6	4	7	31	32

Table G-27. Hatch Cover Assembler 3D Static Strength Prediction Program

*3D Static Strength Prediction Program*  
University of Michigan (1997)

Work Phase: Shipboard Rigger Lifting Equipment	Disc Compression (lbs) @ L5/S1 (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs)
<p>Hatch Cover Assembler Picks Up Hatch with One Hand; Estimate Load to be ~ 40 lbs</p> 	<p><b>821 pounds</b></p>

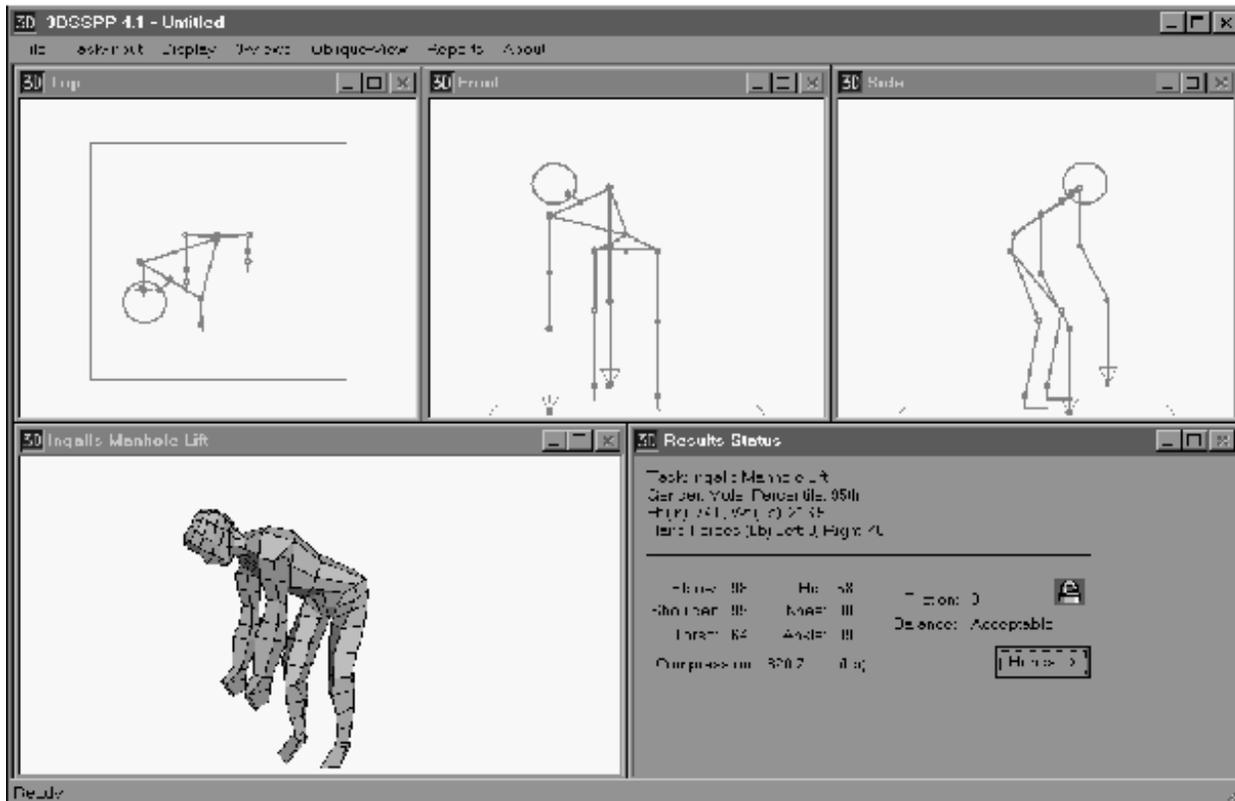


Table G-28. Hatch Cover Assembler PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
1) Find the injured body region, answer yes or no to corresponding questions					
Musculoskeletal Risk Factor Questions	Body Regions				
	Neck, Shoulder, and Upper Back	Elbows, Forearms, and Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			Y	Y	Y
7: Is fatiguing foot pedal work performed?			Y	Y	
8: Is fatiguing leg work performed? e.g. ...					
a) repeated stepping up on stool, step etc..			Y	Y	Y
b) repeated jumps, prolonged squatting or kneeling?			Y	Y	Y
c) one leg being used more often in supporting the body?			Y	Y	Y
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table G-28. Hatch Cover Assembler PLIBEL (continued)

10: Is repeated/sustained work performed with neck:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Note important factors:					
a) periods of repetitive lifting	N				N
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	N				N
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	N	N			N
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	N	N			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table G-28. Hatch Cover Assembler PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, and Upper Back	Elbows, Forearms, and Hands	Feet	Knees and Hips	Low Back
SUM	13	6	2	2	10
PERCENTAGE	50	54.5	25	25	47.6
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work?	N				
20: Is the job performed under time demands or psychological stress?	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	N				
b) heat	Y				
c) draft	N				
d) noise	Y				
e) troublesome visual conditions	Y				
f) jerks, shakes, or vibration	Y				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	4				
PERCENTAGE	40.0				

## G6. RECIPROCATING SAW OPERATOR

Table G-29. Reciprocating Saw Operator RULA

*Rapid Upper Limb Assessment (RULA)*  
Matamney and Corlett (1993)

Work Phase	Sawing Sheetmetal Duct on Floor		Sawing Sheetmetal Duct on Floor		Changing Saw Blade		Planning Cuts and Methods		Workpiece	
	Specific	Score	Specific	RULA Score	Specific	RULA Score		RULA Score	Specific	RULA Score
Shoulder Extension/ Flexion	sl flex	2	sl flex	2	sl flex	2	sl flex	2	mod flex	3
Shoulder is Raised (+1)		0		0		0		0		0
Upper Arm Abducted (+1)		0		0		0		0		0
Arm supported, leaning (-1)		0		0		-1		-1		0
Elbow Extension/ Flexion	ext	1	neut	2	ext	1	ext	1	ext	1
Shoulder Abduction/ Adduction	add	1	add	1	add	1	neut	0	neut	0
Shoulder Lateral/ Medial	neut	0	neut	0	neut	0	neut	0	med	1
Wrist Extension/ Flexion (left)	ext	2	ext	2	ext	2	neut	1	ext	2
Wrist Deviation	ulnar	1	ulnar	1	ulnar	1	neut	0	neut	0
Wrist Bent from Midline (+1)		0		0		0		0		0
Wrist Twist (1) In mid range or (2) End of range		1		1		1		1		1
Arm and Wrist Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		0		1
Arm and Wrist Force/ load Score: If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		3		3		1		0		3

Table G-29. Reciprocating Saw Operator RULA (continued)

Work Phase	Sawing Sheetmetal Duct on Floor		Sawing Sheetmetal Duct on Floor		Changing Saw Blade		Planning Cuts and Methods		Repositioning Workpiece	
	<i>Specific</i>	<i>Score</i>	<i>Specific</i>	<i>RULA Score</i>	<i>Specific</i>	<i>RULA Score</i>		<i>RULA Score</i>	<i>Specific</i>	<i>RULA Score</i>
Neck Extension/ Flexion	flx	3	flx	3	flx	3	sl flx	2	sl flx	2
Neck Twist (+1)		0		0		0		0		0
Neck Side-Bent (+1)		0		0		0		0		0
Trunk Extension/ Flexion	sl flex	2	mod flx	3	sl flex	2	sl flex	2	mod flx	3
Trunk Twist (+1)		0		0		0		0		0
Trunk Side Bend (+1)		0		0		0		0		0
Legs: If legs and feet are supported and balanced: (+1); If not: (+2)		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or if action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		1		1
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		2		2		2		2		2
<b>Total RULA Score</b>	<b>7</b>		<b>7</b>		<b>6</b>		<b>4</b>		<b>7</b>	
1 or 2 = Acceptable 3 or 4 = Investigate Further 5 or 6 = Investigate Further and Change Soon 7 = Investigate and Change Immediately										

Table G-30. Reciprocating Saw Operator Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>6.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion = $100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$ = $100 \times \frac{1114 \text{ (sec)}}{1224 \text{ (sec)}}$ = 91%	< 10%	1	0.5
	10% - 29%	2	1.0
	30% - 49%	3	1.5
	50% - 79%	4	2.0
	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>3.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute = $\frac{\text{number of exertions}}{\text{total observation time (min)}}$ = but task nearly static, set multiplier to 3.0	< 4	1	0.5
	4 - 8	2	1.0
	9 - 14	3	1.5
	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>3.0</b>

Table G-30. Reciprocating Saw Operator Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
Rating Criterion	Wrist Extension	Wrist Flexion	Ulnar Deviation	Perceived Posture	Rating	Multiplier
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation (*estimated, based on RULAs done)	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>2.0</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
Rating Criterion	Observed Pace/MTM Predicted Pace x 100%	Perceived Speed	Rating	Multiplier
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:	Rating Criterion	Rating	Multiplier
Duration of Task per Day (hrs)	< or = 1 hr	1	0.25
= duration of task (hrs) +	1 – 2 hrs	2	0.50
duration of task (hrs) + ...	2 – 4 hrs		0.75
= (estimate ~ 2- 4 hrs)	4 – 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>0.75</b>

Table G-30. Reciprocating Saw Operator Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.						
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	<u>SI SCORE</u>
6.0 X	3.0 X	3.0 X	2.0 X	1.0 X	0.75	= <u>81</u>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table G-31. Reciprocating Saw Operator UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

<b>Risk Factors</b>	<b>No</b>	
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?	N	
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	N	
3.5 Can the worker be seated while performing the job?		Y
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N	
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N (Pistol grip)	
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?	N (left hand)	
6.3 Is the handle of the tool made from material other than metal?		Y
6.4 Is the weight of the tool below 4 kg (9lbs)?		Y
6.5 Is the tool suspended?	N	
<b>TOTAL</b>	<b>16 (73%)</b>	<b>6 (27%)</b>

Table G-32. Reciprocating Saw Operator OWAS

*OWAS: OVAKO Work Analysis System*  
Louhevaara and Suurnäkki (1992)

Work Phase	Sawing sheet-metal duct, on floor	Move saw	Sawing sheet-metal duct, on floor	Move body	Transfer saw from person to person	Plannin g cuts to be made, and methods	Move work-piece	Change saw blade
TOTAL Combination Posture Score	2	2	2	2	1	1	2	2
Common Posture Combinations (collapsed across work phases)								
Back	2	1						
Arms	1	1						
Legs	6	6						
Posture Repetition (% of working time)	84	13						
Back % of Working Time Score	3	1						
Arms % of Working Time Score	1	1						
Legs % of Working Time Score	3	1						
<b>ACTION CATEGORIES:</b> 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately								

Table G-32. Reciprocating Saw Operator OWAS (continued)

<b>Work Phase</b>	<b>Sawing Sheet-metal Duct on Floor</b>	<b>Move Saw</b>	<b>Saw Sheet-metal Duct on Floor</b>	<b>Move body</b>	<b>Give Saw to Other Person</b>	<b>Plan Cuts and Method</b>	<b>Move Work-piece</b>	<b>Change Saw Blade</b>
<b>Posture</b>								
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2	2	2	2	1	1	2	2
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	2, 6	6	6	6	6	6	6	6
<b>Load/ Use of Force</b>								
1 = weight or force needed is = or <10 kg (<22lbs) 2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs) 3 = weight or force > 20 kg (>44 lbs)	2	1	2	2	1	1	3	1
<b>Phase Repetition</b>								
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	50	4	8	3	1	12	6	13

Table G-33. Reciprocating Saw Operator NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
Waters and Putz-Anderson, (1996)

\* “YES” responses are indicative of conditions that pose a risk of developing low back pain;  
the larger the percentage of “YES” responses, the greater the risk.

<b>RISK FACTORS</b>	<b>YES</b>	<b>NO</b>
<b>General</b>		
1.1 Does the load handled exceed 50 lbs?		N
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?		N
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?		N
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (extended kneeling)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?	Y (full body PPE)	
1.9 Does the task require working in a confined area?		N
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N
2.2 Does the vertical lifting distance exceed 3 feet?		N
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?	Y (holding sawsall)	
2.5 Do extended reach static holding tasks exceed 1 minute?	Y (holding sawsall)	
<b>TOTAL</b>	<b>6 (43%)</b>	<b>8 (57%)</b>

Table G-34. Reciprocating Saw Operator PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions					
2) Answer questions, score potential body regions for injury risk					
<b>Musculoskeletal Risk Factor Questions</b>	<b>Body Regions</b>				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			Y	Y	Y
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N

Table G-34. Reciprocating Saw Operator PLIBEL (continued)

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	N				N
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	Y				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		Y			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table G-34. Reciprocating Saw Operator PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	17	9	2	2	12
PERCENTAGE	65.4	81.8	25.0	25.0	57.1
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21: Can the work have unusual or expected situations?	Y				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	N				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	Y				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	5				
PERCENTAGE	50.0				